A New Interferometer for Monitoring Atmospheric Phase Fluctuations

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Background

Water vapor in the Earth's troposphere introduces extra electrical path in the propagation of radio signals through the atmosphere. The distribution of water vapor is irregular and distorts the wavefronts of incoming radio waves, limiting the angular resolution that can be achieved with ground-based telescopes. The level of fluctuations depends both on the location of the site and on the prevailing atmospheric conditions. The ability to measure the fluctuations is therefore important when choosing a site for a new instrument, and for scheduling observations of existing telescopes.

Existing phase monitors are radio interferometers that monitor monochromatic beacon tones from geostationary communications satellites at a frequency of ~12 GHz. They have a classical heterodyne design based on two satellite receiving antennas; each has a frontend for amplifying and downconverting the incoming signals using a local oscillator that is phase-locked to a common reference frequency. In addition to multiple phase-locked loops these instruments require expensive phase-stable cabling to reduce the effects of thermal drift.

New Design

The new system uses two consumer 18" digital satellite TV dishes to monitor satellite TV broadcast signals over a bandwidth of 500 MHz (12.2 to 12.7 GHz). The novel design eliminates the need for phase-locked loops and thermally stable components, and uses a pair of Gilbert Cell multipliers to perform the broadband correlation. A phase monitor has been been built and deployed at the site of the Berkeley-Illinois-Maryland Association Millimeter Array in Northern California, and has been operating successfully since June 1998, measuring the difference in electrical path length for parallel lines of sight to the satellite separated by a baseline of 100 m. With a hardware cost of approximately $4000, it is much cheaper than previous instruments, and the low power requirements and high reliability make the system suitable for site testing in remote locations.

Plots showing current conditions at the site and a detailed description of the instrument can be found at http://bima2.berkeley.edu/phasemon/phasemon.html.